

SkyBridge does not agree that NGSO systems should be required to protect larger inclinations to the same level as non-inclined systems, as this would necessarily place significant capacity and cost constraints on such systems. For an NGSO system designed to just meet the EPFD limits for non-inclined systems to guarantee exactly the same EPFD to any GSO system operating in slightly-inclined orbit, the NGSO system would have to decrease its power or increase the extent of its orbital arc avoidance to satisfy such a requirement. In effect, the system would be required to reduce its EPFD to non-inclined systems below the permissible limits, which would result in over-protecting the vast majority of GSO systems, and constraining the NGSO system. Moreover, it is not at all clear how compliance with any such requirement would be verified. Detailed simulations of the impact of each NGSO system on each inclined-orbit system under consideration would be required, an undertaking not contemplated by the JTG software tool under consideration, or by any generic simulation tool.

In sum, in the absence of any studies demonstrating actual harm to any slightly-inclined GSO system by NGSO FSS systems, and in view of the substantial evidence that such systems will be inherently protected by the measures already taken to protect non-inclined systems, SkyBridge urges the Commission to refrain from imposing a special requirement for the protection of slightly-inclined systems. Such a requirement would unnecessarily burden NGSO FSS systems, and would not be

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<sup>75/</sup> (...continued)  
that 60 cm dishes will not generally be used by inclined orbit systems, which must use tracking antennas.)

consistent with the Commission's long-standing policy toward slightly-inclined orbit systems.

### 3. GSO TT&C

#### a. Operational Orbit

There appears to be a general consensus within the ITU-R study groups, reflected in the comments, that the EPFD and EPFD<sub>up</sub> limits under consideration should adequately protect GSO command and telemetry links in normal mode of operation, and that no additional measures are required.<sup>76/</sup>

Without making any attempt to show that this conclusion is wrong, PanAmSat proposes that the Commission take an inventory of the bands used for TT&C and prohibit NGSO operation in the TT&C bands.<sup>77/</sup> In fact, such an approach was considered and rejected at the first JTG meeting, because GSO FSS T&C operations are scattered throughout the Ku-band.<sup>78/</sup> In the absence of any evidence whatsoever that such a requirement is necessary, the Commission should follow the lead of the ITU-R studies, and conclude that operational phase TT&C will be adequately protected by the same measures taken to protect other communications to and from the GSO arc.

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<sup>76/</sup> See, e.g., Loral Comments at 7-8; Boeing Comments at 28.

<sup>77/</sup> PanAmSat Comments at 25-26.

<sup>78/</sup> See Document 4-9-11/66.

**b. Transfer Orbit**

There is clearly consensus that, for transfer orbit maneuvers, GSO (FSS and BSS) and NGSO FSS licensees should consult with each other to ensure successful deployment of the GSO spacecraft and operation of the NGSO system.<sup>79/</sup>

**c. Emergency Situations**

There is also agreement that, in case of *force majeure*, an operator (GSO or NGSO) should be permitted to use all means at its disposal to reacquire communications and regain control of its spacecraft. As in the case of transfer orbit maneuvers, a dialogue between operators (GSO and NGSO), on a case-by-case basis, is needed to facilitate the resolution of any *force majeure* event.<sup>80/</sup>

**4. NGSO Failures**

As SkyBridge described in its comments, just as with GSO systems, there are sufficient incentives for NGSO operators to avoid failures that could have an impact on other systems. Additional regulatory procedures or requirements are not needed to ensure NGSO satellite failures do not burden other services. No commenter disagreed with this assessment.

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<sup>79/</sup> GE Comments at 23; Loral Comments at 7; Boeing Comments at 27; Telesat Comments at 7.

<sup>80/</sup> GE Comments at 24; Loral Comments at 7.

#### IV. NGSO FSS SHARING WITH GSO BSS

##### A. Results of ITU-R Studies

As discussed in its comments, SkyBridge supports the BSS protection criteria and methodologies developed within the JTG 4-9-11 and JWP 10-11S, and contained in the 10-11S Preliminary Draft New Recommendation ("PDNR").<sup>81/</sup> The BSS operators commenting in this proceeding agree.<sup>82/</sup> Therefore, the Commission should follow the lead of the ITU-R study groups and employ this proposal for the purposes of establishing EPFD masks to be included in the Commission's rules.

Furthermore, noting that the shape of some EPFD masks is more accommodating of NGSO interference statistics than others, DirecTV echoes the agreement at the Long Beach JTG that any aggregate mask that meets the PDNR criteria for all links is acceptable, regardless of shape.<sup>83/</sup> SkyBridge commends DirecTV for its cooperative efforts, which will provide maximum flexibility to NGSO operators, while fully protecting BSS operations. SkyBridge urges the Commission to encourage such approaches with the GSO FSS and FS participants in this proceeding.

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<sup>81/</sup> See SkyBridge Comments at 57.

<sup>82/</sup> Furthermore, DirecTV noted in its comments that both DirecTV and SkyBridge have developed software implementations of the PDNR methodology, and they agree closely with each other. DirecTV Comments at 9.

<sup>83/</sup> DirecTV Comments at 10; Document 4-9-11/TEMP/93.

## B. EPFD Limits

The BSS operators urge the Commission not to adopt the WRC-97 limits.<sup>84/</sup> SkyBridge agrees with these parties that the advances made within the ITU-R working groups, discussed above, should be incorporated into new limits.

With this in mind, employing the ITU-R methodology and techniques, SkyBridge derived aggregate EPFD masks, which were then used to derive single entry EPFD masks.<sup>85/</sup> In its comments, SkyBridge proposed single entry EPFD masks for 45 cm, 100 cm, 120 cm, and 180 cm GSO BSS reference antenna sizes for Region 2. SkyBridge based its analysis on the links then contained in the CR 92 database. Now that additional links have been added to the database, SkyBridge will revisit its derivations.

One point of disagreement between SkyBridge and DirecTV is DirecTV's position that the PDNR protection criteria must be met for all BSS links in the CR 92 database.<sup>86/</sup> As discussed in Appendix B of the SkyBridge comments, some of the links currently in the database have peculiar characteristics that make it difficult for NGSO systems to achieve protection with the PDNR approach.<sup>87/</sup> For such links, it is important to look at the specific characteristics of the link, and examine on a case-by-case basis whether harmful interference will occur with a given

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<sup>84/</sup> DirecTV Comments at 2,8; EchoStar Comments at 3; USSB Comments at 4; Denali Comments at 11.

<sup>85/</sup> See SkyBridge Comments at 32.

<sup>86/</sup> DirecTV Comments at 10.

<sup>87/</sup> It should be noted that most of these links were submitted by foreign administrations, and do not correspond to links operated by U.S. licensees.

set of candidate limits. While SkyBridge agrees that it is important to study all links, SkyBridge cannot agree that the PDNR approach is sufficient in all cases. For certain unusual links, further analysis is required, to avoid overly and unnecessarily constraining NGSO FSS systems.

For example, most of the links in the CR 92 database for large BSS dishes (120 cm and 180 cm) exhibit extreme characteristics (edge of coverage, very low EIRP, and very low margin).<sup>88/</sup> Such links need to be examined carefully, because their protection according to the generic PDNR analysis would lead to extraordinarily stringent limits that would be applied to NGSO FSS systems worldwide. One point that has to be taken into account with such links is that phenomena that have been ignored in the generic analysis because they were considered second order in the statistics of link performance (e.g., propagation variations at low elevation, sun outages, gain variations) are of first order importance for such links.<sup>89/</sup> Accordingly, SkyBridge is conducting a case-by-case analysis of such links. The limits proposed by SkyBridge in Appendix B of its comments were based on maintaining a reasonable level of coherence and scalability among the masks for the various antenna sizes.<sup>90/</sup>

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<sup>88/</sup> Moreover, as explained in Appendix B of the SkyBridge Comments, protection of these links is very sensitive to the EIRP of the link; small increases in the EIRP lead to dramatic decreases in the percentage change in unavailability due to NGSO systems.

<sup>89/</sup> It is also important to assess the ability of such extraordinarily sensitive links to withstand interference from other GSO systems.

<sup>90/</sup> This will, for example, aid in producing interpolations for predicting the EPFD experienced by antennas of sizes other than those for which limits are contained in the Radio Regulations and Commission rules.

Like SkyBridge, DirecTV and EchoStar proposed EPFD limits (although EchoStar proposed only an aggregate mask). Although some convergence is evident,<sup>91/</sup> SkyBridge cannot agree with the limits proposed by these parties for the following reasons.

EchoStar proposed the same masks that were submitted by the United States to the Long Beach JTG meeting,<sup>92/</sup> and these masks do not take into account any of the agreements reached at that meeting. For example, the masks are not adapted to fit the interference statistics of NGSO systems, as was agreed at that meeting. Finally, the EchoStar masks are not supported by any technical demonstration of their ability to protect BSS links while not unduly constraining NGSO FSS systems.

While DirecTV has taken steps to make its masks more compliant with the principles adopted at Long Beach, they suffer some of the same defects. By using an almost staircase shape for its masks, DirecTV penalizes NGSO systems by not taking into account the NGSO interference statistics, which, as noted above, DirecTV agreed to do in its own comments. Moreover, DirecTV does not appear to have taken into account the way in which the interference from multiple NGSO systems aggregates. As described in detail in the SkyBridge Comments,<sup>93/</sup> an aggregate mask cannot be converted to a single entry mask (or vice versa) by dividing (or

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<sup>91/</sup> This is particularly the case for the masks protecting small BSS dishes. The aggregate 45 cm mask proposed by SkyBridge is in fact more stringent than DirecTV's. The difference comes in deriving the single entry mask.

<sup>92/</sup> Document 4-9-11/321.

<sup>93/</sup> See SkyBridge Comments at 26.

multiplying) the entire mask by the assumed number of NGSO systems, as DirecTV appears to have done. This further acts to unnecessarily penalize NGSO systems. Although DirecTV states that its masks protect all the links in the CR 92 database, it is not clear that DirecTV has assessed its masks against all the CR 92 links. DirecTV appears to have only checked a sample of the links. The sensitivity of a link varies with the shape of the EPFD mask, so it is difficult to choose the most sensitive links out of the database. A more vigorous assessment is required.

Finally, in deriving single entry masks, DirecTV used a "conservative estimate" of 5 for the value of "N".<sup>94/</sup> As SkyBridge (as well as Loral and Boeing) discussed in its comments, studies in WP 4A suggest that even  $N=3$  is very a conservative estimate, when considerations such as the constraints imposed on each NGSO system, and the resulting impact to capacity and economic viability, are taken into account. Pending further studies on this issue, SkyBridge does not see any justification for use of any higher value than 3 for the number of systems. As discussed below, the international coordination procedure currently being developed will help ensure that BSS systems are protected, even if the number of systems that ultimately enter the band is greater than the number used to derive the single entry limits.

As with the GSO FSS operators, the BSS licensees urge that a strong regulatory mechanism is needed to ensure that the aggregate is never exceeded.<sup>95/</sup> SkyBridge sympathizes with this concern. The international regulatory regime

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<sup>94/</sup> DirecTV Comments at 19.

<sup>95/</sup> DirecTV Comments at 10, 19.



contemplated by the JTG<sup>96/</sup> would have the objective of allowing NGSO systems to coordinate amongst themselves<sup>97/</sup> to permit additional entry, while ensuring that the aggregate mask is met. The details of this regime remain to be finalized at the international level.

**C. Other Considerations**

**1. Airborne BSS**

The Commission raised in the NPRM the issue of protection of airborne BSS antennas. As SkyBridge discussed in its comments, it appears that airborne BSS services and NGSO FSS systems could co-exist under the presently proposed technical parameters. Although, as DirecTV explains, these links typically use receive antennas that have a fan beam,<sup>98/</sup> it does not appear to be the case that the gain of the antennas is significantly lower than that of 45 cm dishes used on the ground.<sup>99/</sup> Moreover, although some sidelobes are higher as compared to a terrestrial BSS antenna, others are much lower. As a result, when the time-varying nature of NGSO interference is taken into account (along with the movement of the airplane), it appears that airborne antennas will not be more sensitive to interference than terrestrial BSS antennas.

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<sup>96/</sup> See SkyBridge Comments at 30 and Section III.A.2 above.

<sup>97/</sup> See Radio Regulations S9.12, which governs coordination between NGSO systems.

<sup>98/</sup> DirecTV Comments at 17.

<sup>99/</sup> See Reply Comments of EMS Technologies, Inc., being filed simultaneously herewith.

Although SkyBridge agrees with Boeing that there should be no special requirements for the protection of airborne antennas, SkyBridge is confident that such antennas will be protected in practice, and, like DirecTV,<sup>100/</sup> encourages on-going studies of this issue.<sup>101/</sup>

## **2. Future BSS Systems**

In its comments, SkyBridge agreed with the Commission that improved BSS service should not be stifled by NGSO FSS entry. However, SkyBridge pointed out that (1) future systems can plan for the NGSO FSS environment, and (2) any evolution of BSS systems and services must be consistent with the current GSO environment, which already acts to constraint some kinds of change. No party disputed these points.

DirecTV and EchoStar pointed out two changes that they expect to take place in the future, although neither tries to argue that NGSO entry under any of the proposed limits would pose a burden to these changes.

First, DirecTV states that BSS providers are virtually certain to need to operate their spacecraft at higher EIRP levels.<sup>102/</sup> SkyBridge has already addressed this issue on a number of occasions. As discussed in its Opposition to the Petitions to Deny its Application,<sup>103/</sup> SkyBridge explained that the ability of GSO operators to

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<sup>100/</sup> DirecTV Comments at 17-18.

<sup>101/</sup> Boeing argues that DBS providers should develop mobile antennas with the Article S22 limits in mind. Boeing Comments at 48.

<sup>102/</sup> DirecTV Comments at 14.

<sup>103/</sup> Opposition of SkyBridge, File Nos. 48-SAT-P/LA-97, 89-SAT-AMEND-97, filed February 20, 1998 ("SkyBridge Opposition"), at 42-44.

raise power is limited by the fact that, at some point, interference will be caused to adjacent GSO systems. Moreover, higher GSO EIRPs only serve further to protect such systems from NGSO interference. In SkyBridge's 1997 Amendment,<sup>104/</sup> and again in its Opposition,<sup>105/</sup> SkyBridge assessed the impact on the SkyBridge System of GSO EIRP power increases, demonstrating SkyBridge's ability to cope with the present and future GSO arc situation. As EIRPs are raised, GSO operators, such as DirecTV, are likely to cause interference to adjacent GSO systems long before the SkyBridge System is severely impacted.

Second, EchoStar stated that it plans to deploy "double-feed" dishes capable of receiving signals from two orbital locations.<sup>106/</sup> In such case, the link associated with each feed must be considered separately, and the important parameter becomes the antenna pattern seen by each feed. In fact, the data used to derive the JTG antenna patterns<sup>107/</sup> included a three-feed antenna used in Norway, so such considerations have already been taken into account by the ITU-R study groups.

### 3. GSO TT&C

For protection of GSO BSS TT&C, the Commission should follow the proposal outlined for GSO FSS, which is in line with that contemplated by the JTG.

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<sup>104/</sup> See 1997 Amendment, Appendix C, Section III.

<sup>105/</sup> SkyBridge Opposition at 42-44.

<sup>106/</sup> EchoStar Comments at 5.

<sup>107/</sup> See SkyBridge Comments at 99 and Section VII.D.1.b below.

DirecTV supports the JTG decisions on TT&C,<sup>108/</sup> and no party opposed this proposal.

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<sup>108/</sup> DirecTV Comments at 15.

## V. NGSO FSS SHARING WITH FS

SkyBridge agrees with the Fixed Wireless Communications Coalition ("FWCC") that it is critical to establish rules on emissions and coordination procedures that protect from the outset against interference between co-primary NGSO FSS and FS systems.<sup>109/</sup> For this reason, SkyBridge proposed in its Petition for Rulemaking and its comments a comprehensive regulatory regime that will protect FS operations and expansion, without imposing unnecessary burdens on NGSO FSS systems. SkyBridge's proposals place significant constraints on NGSO FSS deployment and operation, yet SkyBridge believes that they represent a reasoned -- and unprecedented -- accommodation to the FS industry.

In contrast, the FWCC simply compiled a "laundry list" of demands, none of which are supported by any demonstration that they will actually achieve their stated objectives. The FWCC even went so far as asking SkyBridge to change its modulation technique, without any evidence that the Coalition understands the design considerations that go into satellite system design. The Commission should not succumb to the FWCC's simple but arbitrary proposals, but should strive to implement a well-reasoned set of ground rules that optimize the use of the bands for both services.<sup>110/</sup>

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<sup>109/</sup> FWCC Comments at 15.

<sup>110/</sup> In urging the Commission to adopt rules that meet the needs of the NGSO operators to the greatest extent possible, SkyBridge is in no way departing from its proposed principle, stated in its Petition for Rulemaking, that the entry of NGSO systems should cause no noticeable degradation to FS operations, and impose no operational constraints on existing systems. See FWCC Comments at 2-3; TIA Comments at 2. There are many ways to protect FS operations, some of which are simply more accommodating to  
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### A. Gateway Operation

SkyBridge supports the Commission's proposal to limit NGSO FSS use of certain Ku-bands to gateway operations only. SkyBridge disagrees with Teledesic's argument that the Commission should not regulate earth station function.<sup>111/</sup> If the Commission were to allow user terminals in these bands, even if subject to the same coordination requirements with FS links as gateway earth stations, deployment of ubiquitous user terminals in any area in which there is currently little or no FS deployment would "sterilize" that region for future FS expansion, a result that SkyBridge has taken great pains, at its expense, to avoid. Although apparently not fully appreciated by the FS community, SkyBridge's proposals for sharing of the band strike a much more equitable balance between the needs of the FS and NGSO operators, and further the Commission's dual goals of permitting NGSO entry while preserving room for FS expansion.

Virgo argues that user terminals should be permitted to operate in the 11.2-11.7 GHz band, so long as they are capable of switching automatically to other frequency channels where there is no FS interference (such as in the 11.7-12.2 GHz band) in the event that they find unacceptable interference from the FS, either at the

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<sup>110/</sup> (...continued)  
NGSO FSS systems than others. In deciding between options that protect FS operation and expansion, there is no rational reason not to choose the one that places the least constraints on NGSO systems. While SkyBridge has taken great pains to accommodate co-primary FS operations, the FS community appears unwilling to reciprocate.

<sup>111/</sup> Teledesic Comments at 6-7.

time of installation, or any time in the future.<sup>112/</sup> While SkyBridge has no problem with this proposal, the FS community may well have concerns related to how the frequency hopping would actually be accomplished.

As SkyBridge detailed in its comments, supported by Comsearch studies commissioned by SkyBridge, the required separation distances between NGSO FSS gateways and FS stations are expected to be on the order of a few tens of kilometers, or even a few kilometers if shielding (natural or artificial) is used to further reduce separation distances. With an appropriate definition for "gateway" operations, and a coordination procedure that contemplates use of shielding as necessary, the two services will be able to share without undue constraints on either service, and without the imposition of burdensome and arbitrary geographic or technical limitations on NGSO FSS operations.

#### **1. Gateway Definition**

After careful consideration of the needs of FS operators, and the ways in which non-gateway operations (such as master antennas) might be able to "slip in" under the Commission's proposed definition for "gateway earth station complexes,"<sup>113/</sup> SkyBridge proposed in its comments a tighter definition. However, SkyBridge agrees with the proposal of Boeing that TT&C operations should also be permitted at gateway complexes.<sup>114/</sup> With this in mind, SkyBridge would add a sentence to its proposed definition as follows:

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<sup>112/</sup> Virgo Comments at 13.

<sup>113/</sup> PanAmSat, for example, agreed that the Commission's proposed definition may be too broad. PanAmSat Comments at 16.

<sup>114/</sup> Boeing Comments at 78.

Gateway earth station complexes provide satellite radio frequency resources to NGSO FSS network user earth stations within each gateway coverage area, and thereby interconnect the user earth stations with other networks. Such complexes may also be used for TT&C transmissions.

SkyBridge opposed the Commission's proposed rule requiring that each complex must be located within a one second latitude and longitude square. Boeing agreed with SkyBridge that the approximately 30 m by 30 m zone demarcated by this rule is simply too small for true gateway operations.<sup>115/</sup> Therefore, the Commission should abandon this proposed requirement. In fact, the FS community should be encouraged by these objections; large complexes will be few and far between, and given real estate costs, unlikely to be situated in urban areas.<sup>116/</sup>

Some parties urge that in lieu of, or in addition to, the gateway definition, the Commission should adopt a minimum gateway earth station antenna size. PanAmSat proposes 3 meters,<sup>117/</sup> while Boeing proposes 4.5 m.<sup>118/</sup> Neither of these proposals is based on any technical rationale or demonstration of the benefit purportedly achieved by these proposals. In fact, any antenna size limitation will necessarily be entirely arbitrary, and act to unnecessarily constrain NGSO system. Furthermore, the sidelobe pattern of these large antennas will not differ appreciably

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<sup>115/</sup> Boeing Comments at 80-81. SkyBridge opposes the Commission's proposed rule to permit "only one gateway earth station complex within each NGSO spacecraft antenna beam." No party commented on this proposal, and SkyBridge urges the Commission to abandon this requirement as being unduly constraining on NGSO FSS flexibility with no appreciable benefit for any other party.

<sup>116/</sup> Boeing, for example, notes in its comments that it plans only 2 gateways in the continental United States. Boeing Comments at 30.

<sup>117/</sup> PanAmSat Comments at 16.

<sup>118/</sup> Boeing Comments at 79.



from smaller ones. As was demonstrated in a Comsearch study attached as Appendix C to the SkyBridge Comments, the separation distances for antennas within the range of 2.5-4.5 m will be substantially the same. SkyBridge urges the Commission to act to limit the number of gateways via the more rational approach of tightly circumscribing the kinds of operations that can be conducted at gateway complexes. This will better facilitate NGSO/FS sharing in these bands.

## **2. Coordination of NGSO FSS Gateways and FS Stations**

### **a. Coordination Procedures**

SkyBridge supports the Commission's proposal to use existing coordination procedures to facilitate sharing among NGSO FSS gateways and FS links.<sup>119/</sup> As detailed in its comments, SkyBridge proposes that the Commission apply the technical aspects of the coordination in Appendix 28/Appendix S7 of the ITU Radio Regulations, as revised by WRC-2000, for NGSO (and GSO) systems.

Comsearch, a recognized authority on coordination issues, agrees that the existing coordination procedures should apply. Comsearch states that the NGSO earth station contours can be calculated using the IS.849 modifications to the existing IS.847 method. SkyBridge agrees that these should be used as an interim procedure until the revisions to Appendix 28/Appendix S7 are adopted at WRC-2000. Comsearch concludes that the GSO coordination data set needs some modification to apply to NGSO systems, and proposes that industry groups, such as the National

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<sup>119/</sup> See also Boeing Comments at 30.

Spectrum Managers Association, suggest appropriate changes.<sup>120/</sup> SkyBridge fully supports this approach.

The FWCC, on the other hand, disagrees with the Commission's proposal to carry over the procedures for GSO coordination to NGSO coordination.<sup>121/</sup> The FWCC argues that coordinating with NGSO gateways will be far more difficult than with GSO earth stations, because they "sterilize" a much larger area.<sup>122/</sup> This comment reflects a fundamental misunderstanding of NGSO FSS operation, which SkyBridge has attempted to clarify for the FS community on numerous prior occasions.<sup>123/</sup> The FWCC seems to believe that the greater range of pointing azimuths of an NGSO gateway will act to prevent FS deployment in a much larger area. However, the coordination area defines only the region in which a detailed interference analysis becomes necessary; it does not define any area that will be "sterilized." It is important to take into account the pointing direction of the FS link to be installed; indeed in many respects, this is the most critical variable. Moreover, as the Commission recognized, the coordination area is actually smaller for NGSO gateways than for GSO earth stations.<sup>124/</sup> There is no evidence that coordination with

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<sup>120/</sup> Comsearch Comments at 2-3, 5.

<sup>121/</sup> FWCC Comments at 18.

<sup>122/</sup> FWCC Comments at 6, 18.

<sup>123/</sup> See, e.g., Opposition of SkyBridge in File Nos. 48-SAT-P/LA-97, 89-SAT-AMEND-97, filed February 20, 1998, at 67.

<sup>124/</sup> NPRM at 22. In fact, the U.S. preliminary view on the treatment of probabilistic components of interference, and the use of Appendix S7, is as follows: "The United States recognizes that the existing methodology in Appendix S7 has worked well and that unnecessary larger coordination areas  
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NGSO gateways will be more difficult or burdensome than coordination with GSO earth stations.

The FWCC goes on to propose that the FS operator should have to coordinate only over the azimuths actually used by an NGSO gateway.<sup>125/</sup> In fact, it can be expected that all azimuths will be used by each NGSO gateway. However, the minimum elevation angle used may vary greatly depending on azimuth. This is one of the reasons that the Commission should employ the revision to Appendix 28/S7, which takes into account the time-varying nature of the horizon gain of the NGSO gateway antenna for a given azimuth. This leads to a smaller coordination area, facilitating coordination with FS links.

The FWCC also proposes that if an NGSO gateway accepts a higher-than-desired interference objective when coordinating, then an FS facility that subsequently coordinates should have the benefit of the same higher level.<sup>126/</sup> SkyBridge can agree to that proposal, which should be applied to any coordination and to both services (i.e., FS and FSS).

Finally, as part of its "laundry list," the FWCC proposes two patently unsupportable proposals. First, the FWCC proposes that NGSO gateways should be required to specify half of the band to be left available for FS growth.<sup>127/</sup> With

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<sup>124/</sup> (...continued)  
may result from separating the propagation and probability considerations."  
See Agenda Item 1.3 at <http://www.fcc.gov/ib/WRC00/pv990112.html>.

<sup>125/</sup> FWCC Comments at 20.

<sup>126/</sup> Id.

<sup>127/</sup> Id. at 19.

SkyBridge's proposals, however, there is no technical justification for such a requirement. It would simply create an unnecessary constraint on NGSO systems, with no demonstrable benefit for FS systems.

Furthermore, the FWCC proposes that SkyBridge should be required to at least double its spectrum efficiency by using 16-QAM instead of QPSK modulation.<sup>128/</sup> The FWCC fails to take into account the SkyBridge modulation scheme taken as a whole, which is based on spread spectrum modulation. Spread spectrum is very well-suited for an environment where transmission power is a scarce resource, and for systems adapted for frequency re-use with FS and GSO systems. In contrast, terrestrial transmission of digital video signals generally employs modulation methods such as 8-VSB and 64-QAM, which are better suited to the terrestrial propagation environment and cases in which the power transmitted is not that critical. The use of 16-QAM modulation would force SkyBridge to increase the power transmitted by its satellites and earth stations (which would not benefit GSO, NGSO or FS systems) and would make the system more sensitive to interference.

In addition to the 10.7-11.7 GHz and 17.7-17.8 GHz bands used by the FS service, the 12.75-13.25 GHz band is also proposed for NGSO FSS gateway operations. This band is used by fixed cable antenna relay system ("CARS") microwave, fixed broadcast studio-to-transmitter links ("STL"), and temporary or mobile TV pickup stations. As in the other bands, SkyBridge proposes that standard coordination procedures be used to avoid interference among the co-primary services in this band.

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<sup>128/</sup> Id. at 11.

As discussed in its comments, SkyBridge has not opposed the Petition of OpTel to expand the permissible terrestrial uses of the 12.75-13.25 GHz band,<sup>129/</sup> so long as such links are subject to the coordination procedures proposed above.<sup>130/</sup> OpTel stated in its comments that it believes that the band can be shared successfully by terrestrial users and NGSO gateway uplink stations. Moreover, OpTel provided assurance that its proposed use of the band will be consistent with the current use of the band by CARS licensees,<sup>131/</sup> and will be subject to coordination with NGSO FSS services.<sup>132/</sup>

The Society of Broadcast Engineers ("SBE") argues that sharing with TV pickup stations in the 12.7-13.25 GHz band is not possible, because the receive ends are mobile, or are remotely steered to aim towards the temporary location of a TV pickup transmitter (e.g., for electronic news gathering), and therefore, coordination is not possible.<sup>133/</sup> However, for these reasons, TV pickup stations operate on a secondary basis in this band, and are not entitled to interference

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<sup>129/</sup> Note that the Commission recently denied OpTel's request to use frequencies in the 10.7-11.7 GHz band for fixed point-to-point microwave transmission of video entertainment material on a private carriage basis. DA 99-406, rel. March 10, 1999.

<sup>130/</sup> SkyBridge cautioned the Commission against expanding the terrestrial users of this band to include dissimilar operations, such as point-to-multipoint systems, or use of wide-beam antennas, or to introduce different licensing regimes, such as area-wide licensing. In its comments, Boeing agreed with SkyBridge that such changes would significantly alter the sharing environment in the band, adversely affecting both satellite and current FS users alike. Boeing Comments at 33.

<sup>131/</sup> OpTel Comments at 2.

<sup>132/</sup> Id. at 3.

<sup>133/</sup> SBE Comments at 1-2.

protection. Even today they must operate within an environment where this band is heavily used by CARS and STL transmitters, and they must accept any interference these operations cause. As a result, and because of the propagation features and atmospheric loss in this band, the band is used by TV stations only for relatively short pickup links, and often at ground level where the link is shielded from interfering signals by building blockage. The 2 GHz and 6 GHz broadcast auxiliary bands are used for longer distance pickup links.

**b. Gateway Site Shielding**

In its comments, SkyBridge proposed, in an effort to avoid unnecessary restrictions on FS growth, that NGSO FSS operators assume an obligation, incorporated in the Commission's rules, to accept shielding of gateway complexes, as follows:

(1) If a FS operator proposes to install a new FS link that would otherwise be precluded by an existing NGSO FSS gateway, and the installation of shielding at the gateway would eliminate the preclusion, the FS operator may require the NGSO FSS gateway operator to accept shielding at its gateway site, to the extent necessary to permit the introduction of the FS link, and to the extent possible given the surrounding terrain and buildings and the need to preserve the effectiveness of pre-existing shielding, so long as the shielding does not degrade the performance of the NGSO FSS gateway. In such case, the FS operator shall pay for the costs of the shielding.

(2) In installing a gateway, an NGSO FSS operator shall not be required to install shielding to protect future FS links. The operator could, of course, employ shielding around its gateway complex in order to achieve successful coordination with one or more existing FS links. In such case, the gateway operator would incur the costs of the shielding.

(3) In coordinating new FS links with existing NGSO FSS gateways for which shielding has been implemented, the existing shielding should be taken into account by the new FS link for the detailed interference analysis that follows the coordination request.

SkyBridge believes that this proposal represents a reasoned and fair approach to accommodating both NGSO and FS systems in the band, and will ensure the ability of FS operators to expand their systems, and urges the Commission to adopt it.

In contrast, the FWCC proposed an arbitrary and unnecessary requirement that NGSO gateways install a minimum of 18 dB shielding in all directions.<sup>134/</sup> First, there is absolutely no benefit to installing shielding at a gateway site before any FS link is even proposed in the vicinity. Such a requirement would be a complete waste of resources and of benefit to no one. Furthermore, even if an FS link is proposed, 360° shielding is not required to accommodate such link. Again, the Coalition's proposed requirement would waste resources, with no resulting benefit.<sup>135/</sup>

In addition, as noted in SkyBridge's comments, it must be recognized that there may be situations in which artificial shielding is not feasible, due to terrain features or buildings. Such features in themselves may provide significant shielding, but it cannot be guaranteed in any given case that it would meet any arbitrary requirement, such as 18 dB.

Finally, there must be a sharing of the cost burden involved with shielding to facilitate sharing between these co-primary services. SkyBridge is willing to install shielding at its own expense if that is necessary to site a particular gateway at a location near an existing FS link. Furthermore, SkyBridge is willing to accept

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<sup>134/</sup> FWCC Comments at 9.

<sup>135/</sup> Moreover, as the Comsearch study (SkyBridge Comments, Appendix D) shows, shielding beyond approximately 160° often begins to cause internal reflection problems.

shielding at its site if technically feasible, if this will aid a future FS link to be established. As the Commission is well aware, this is an unprecedented accommodation to future build-out of a co-primary service. However, the NGSO operator must not be required to absorb the cost of such later shielding. This would not be appropriate in the context of co-primary services.<sup>136/</sup>

The FWCC also asks the Commission to require that NGSO gateways be installed at or below ground level, and not be mounted on buildings.<sup>137/</sup> It is not clear what "ground level" means in an area of varying terrain. Moreover, it seems clear from the discussion in Section V.A.1 above that gateways will not be placed on buildings; no building is big enough. In any case, such considerations should be entirely left up to the NGSO operator, which will have to weigh the advantages and disadvantages of any given site, including the coordination and shielding burden it will present to the NGSO.

### 3. Gateway Siting Restrictions

In view of the limited numbers of gateways and small separation distances resulting from application of the rules proposed above, SkyBridge believes restrictions on gateway siting are unnecessary to protect the FS industry and

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<sup>136/</sup> It should be noted that in the general case, an FS operator will have options to installing the proposed link in a manner that will require additional shielding. In many cases, moving the station by a few meters may lead to higher natural shielding. In other cases, an extra hop may be less expensive than additional shielding. As with any coordination it undertakes, the FS operator should have the incentive to choose the most cost-effective solution.

<sup>137/</sup> FWCC Comments at 9.



burdensome to NGSO FSS operators.<sup>138/</sup> As demonstrated in SkyBridge's comments, the Commission's proposed "exclusion zones" fail to accurately define those geographical regions that could benefit from an FS "head-start" (assuming arguendo that one was necessary in any event), and in the process unnecessarily and significantly constrains NGSO FSS operators in selecting the most appropriate gateway sites. SkyBridge agrees with Comsearch that the Commission should use caution to avoid arbitrarily restricting the growth of FSS. If proper engineering techniques are followed by both FS and FSS operators, sharing of the spectrum can be maximized.<sup>139/</sup>

Several parties countered the Commission's proposal of 100 km exclusion zones around the 50 largest population centers. Boeing would halve the Commission's proposal, recommending 50 km zones around the 25 largest population centers, with a sunset after five years.<sup>140/</sup> SBC would double the Commission's proposed zones to extend to 200 km.<sup>141/</sup> The FWCC would expand the expand the Commission's exclusion zones to include corridors 50 km to either side of existing intercity routes, and would not sunset the requirements.<sup>142/</sup> In fact, all of these proposals are completely arbitrary, with not a shred of technical justification. The aim of the proceeding should be to adopt technically justifiable rules that address

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<sup>138/</sup> Boeing pointed out the importance of being able to obtain reliable access to the public switched telephone network and fiber network connections. Boeing Comments at 31.

<sup>139/</sup> Comsearch Comments at 3-4.

<sup>140/</sup> Boeing Comments at 31.

<sup>141/</sup> SBC Comments at 5.

<sup>142/</sup> FWCC Comments at 8.

legitimate concerns without unnecessarily constraining any party. None of these proposals meet this standard.<sup>143/</sup>

Finally, an examination of the Commission's picture of the proposed 100 km exclusion zones shows that gateways would be totally excluded from certain regions of the country, due to overlap of the exclusion zones. Such a restriction would pose an intolerable burden on some kinds of NGSO FSS systems, including SkyBridge, by making it impossible to provide service in those areas.

#### **4. Restrictions on Gateway Antenna Size or Number**

As discussed in its comments, SkyBridge opposes restrictions on gateway antenna size or number, in the absence of any demonstration that such restrictions would actually help solve any identified problem, and in view of the benefit already bestowed by the gateway definition and coordination procedures. No party even attempted to provide any analysis indicating that such restrictions would significantly improve the sharing environment.

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<sup>143/</sup> A further proposal on this topic, made by Denali, urges that in lieu of exclusion zones, the Commission should adopt a rule that stipulates that NGSO systems that operate at low elevation angles must provide protection to FS through EPFD limits that are elevation angle dependent. Denali Comments at 12. Denali's proposal seems to relate to protection of FS from interference from NGSO FSS satellites, a concern that is addressed by the PFD limits, and not the exclusion zones, which are meant to facilitate coordination on the terrestrial path.

PetroCom argues that the entire Gulf region should be designated as an exclusion area for siting gateways. PetroCom Comments at 3. PetroCom argues that this is necessary to protect its VSAT operations in that region. However, PetroCom seems to be confusing measures taken to protect FSS and those taken to protect terrestrial FS. PetroCom's GSO FSS network would be fully protected by the EPFD and EPFD<sub>up</sub> limits, and no exclusion zones are necessary.

The FWCC arbitrarily proposes that the Commission cap the total number of NGSO gateway sites at 40.<sup>144/</sup> The FWCC further proposes that the Commission require the various NGSO providers to collocate their gateways as necessary to achieve a maximum of 40 sites overall.<sup>145/</sup> Finally, the FWCC urges the Commission to prohibit SkyBridge's proposed use of 2.5 m antennas for some gateways, and require a minimum NGSO gateway antenna size of 4.5 m.<sup>146/</sup>

The FWCC makes no attempt to justify these restrictions; it simply included them in its "laundry list" of requests. SkyBridge urges the Commission to take a more thoughtful approach, and weigh the actual benefits and impact of proposed rules. In this case, rather than adopting arbitrary restrictions on gateway size or number, SkyBridge urges the Commission to rely instead on the tighter gateway definition that SkyBridge has proposed, to ensure that gateways are few in number. This will achieve the Commission's objective of preserving FS expansion, without placing unnecessary restrictions on NGSO FSS systems. With respect to collocating gateways of different systems, it must be recognized that gateway locations are very specific to each NGSO system, and gateways cannot arbitrarily be located wherever another operator has chosen to site its gateways.<sup>147/</sup> With respect to

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<sup>144/</sup> FWCC Comments at 6-7. The FWCC seems to mean 40 per system, but this is not clear.

<sup>145/</sup> FWCC Comments at 7.

<sup>146/</sup> FWCC Comments at 10.

<sup>147/</sup> Moreover, NGSO/NGSO coordination will be difficult enough without imposing a meaningless gateway collocation requirement. Indeed, this suggestion by the FWCC seems to reflect the FS community's continued confusion regarding the nature of NGSO FSS systems.

minimum antenna sizes, as explained above, the sidelobe pattern for the 2.5 m and 4.5 m antennas are roughly the same, and therefore the separation distances are similar for both kinds of antennas.

**B. NGSO Satellite PFD Limits**

The JTG has confirmed that the current Article S21 per-satellite PFD limits are adequate for the protection of the FS in the 10.7-12.75 GHz bands. The FWCC, members of which took part in that decision, supports adoption of the Article S21 limits. Therefore, the Commission should proceed to implement these limits.

Despite its support for the JTG decision, however, the FWCC continues to voice several concerns about protection of FS stations from NGSO downlink interference. Although SkyBridge has responded to all of these concerns before, SkyBridge takes this opportunity to once again address these issues.

First, the FWCC states that SkyBridge underestimates the likely incidence of direct mainbeam-to-mainbeam interference to FS operations.<sup>148/</sup> In the case of the SkyBridge System, there cannot be any mainbeam-to-mainbeam interference if the FS receiver elevation is less than 6°, which, according to a Comsearch study, covers 95.7% of FS receivers. Moreover, even for those receivers that exceed this elevation, the SkyBridge System meets the FS short term protection criteria agreed to at the Long Beach JTG meeting (I/N=20 dB never to be exceeded). The JTG has agreed that the PFD limits will ensure that all NGSO systems satisfy this protection criteria.

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<sup>148/</sup> FWCC Comments at 11-12.

The FWCC also expresses concern that the limits do not adequately take into account Automatic Transmitter Power Control ("ATPC").<sup>149/</sup> As explained in the SkyBridge Comments, Correspondence Group 9A ("CG 9A") has developed FS protection criteria that take into account an ATPC range of 13 dB. The FWCC did not challenge the adequacy of this assumption. Moreover, according to the FWCC's own argument,<sup>150/</sup> to the extent that a system operates with a lower power than that for which it has been coordinated, it should accept the consequent increase in sensitivity to interference.

The FWCC argues that the risk of interference from NGSO systems is far greater than from GSOs, even under a common set of PFD limits, and notes that even short-acting interference can have severe consequences, in some cases shutting down an entire system.<sup>151/</sup> The difference between GSO and NGSO interference statistics is precisely why CG 9A has worked hard to define FS protection criteria, especially with regard to the short term. The FWCC provides no evidence that the PFD limits approved based on the adopted criteria will cause such dire consequences to any system.

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<sup>149/</sup> FWCC Comments at 12.

<sup>150/</sup> See Section V.A.2.a above. "[I]f an earth station accepts a higher-than-desired interference objective when coordinating, then an FS facility that subsequently coordinates should have the benefit of the same higher level." FWCC Comments at 20.

<sup>151/</sup> FWCC Comments at 13, 17.

Finally, SBC states it should be the responsibility of the NGSO licensee to resolve any interference to an FS facility entirely at its time and expense.<sup>152/</sup> SBC seems to be unaware that the NGSO FSS and FS allocations are intended to be co-primary. Preventing interference to both services is accomplished by the PFD limits, which prevent interference to FS stations from satellite downlinks, and the coordination process, which facilitates sharing on the terrestrial path between FS stations and NGSO FSS gateways.

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<sup>152/</sup> SBC Comments at 4.

## **VI. NGSO FSS / NGSO FSS SHARING**

To the extent technically feasible, multiple NGSO FSS systems should be accommodated at Ku-band. To achieve this objective, the Commission will have to adopt rules, and enforce them vigorously, to ensure that all NGSO systems permitted to enter are able to share with other NGSO systems, and actually provide the kinds of service the ITU and the Commission seek to encourage.

### **A. Satellite Diversity**

Although SkyBridge agrees with Hughes that it is premature to recommend specific sharing approaches and parameters to promote multiple entry in the Ku-band,<sup>153/</sup> there is one general feature of NGSO systems that should be required to ensure that all systems are capable mitigating interference to other NGSO systems. The Commission should require that all NGSO FSS systems be capable of employing satellite diversity to avoid in-line events with other NGSO FSS systems. While this requirement would act to constrain constellation design to some extent, there is simply not a completely technology-neutral way to ensure the mutual compatibility of multiple systems. Although, as discussed below, some parties in this proceeding are proposing other sharing mechanisms, the constellations that use these other methods are not conducive to providing the global, two-way, interactive broadband services for which the ITU allocated this spectrum, and which are needed to fulfill the mandate of Section 706 of the '96 Act.

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<sup>153/</sup> Hughes Comments at 3.

## 1. LEO/MEO Systems

As explained by Boeing, use of diversity to share spectrum requires operators to build in more space and ground assets than they would otherwise have to.<sup>154/</sup> Thus, NGSO systems are paying a high price for accommodating multiple systems in the band. However, if all constellations have diversity capability, studies show that up to three global, economically viable systems should be able to operate.

Moreover, the kinds of systems that inherently employ satellite diversity represent by far the broadest variety of the proposed NGSO FSS systems. Circular orbit LEO and MEO systems can be designed to have sufficient diversity capability to share, as demonstrated by numerous ITU-R studies.<sup>155/</sup> Although the elliptical-orbit systems proposed to date do not appear to have this ability, there is no reason why elliptical orbit systems that build in more space and ground assets, as the LEOs and MEOs do, should not be able to incorporate this capability as well.

Therefore, a requirement that NGSO systems entering the band be capable of employing satellite diversity to mitigate interference to other co-frequency NGSO systems would not overly constrain NGSO system design, and would ensure that no licensed system imposes an unfair burden on other systems.

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<sup>154/</sup> Boeing Comments at 53.

<sup>155/</sup> However, studies have shown that MEOs can have significantly more difficulty employing satellite diversity than LEOs, most likely due to the larger spot size used and the more limited range of pointing angles.



## 2. QGSO Systems

As discussed in the SkyBridge Comments, classic "Quasi-geostationary" Orbit ("QGSO") systems do not have the ability to employ satellite diversity to mitigate interference to other NGSO systems. Although Denali stated that it did not "wish to assert that the burden of sharing should be borne by all types of NGSO systems other than Quasi-GEO systems," it explained that if QGSOs were required to have diversity capability, "the ground segment costs would be dramatically and unacceptably increased."<sup>156/</sup> However, as explained above, that is a burden already incurred by other NGSO systems.

Due to these difficulties, QGSO proponents in this proceeding argue that QGSO systems should not be subject to the same regime as other NGSOs.<sup>157/</sup> Tonga in particular argues that non-QGSO NGSOs should be required to protect QGSO systems to the same degree as they will be required to protect the GSO systems.<sup>158/</sup> Denali argues that, the greater degree to which a system can co-exist

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<sup>156/</sup> Denali Comments at 3-6; Tonga Comments at 2.

<sup>157/</sup> QGSO proponents draw some strange conclusions in trying to support this distinction. Denali claims that while LEO/MEO NGSOs must extensively coordinate to not interfere with GSOs, QGSOs do not need to take such measures. Denali Comments at 4. In fact, both kinds of systems shut-off beams and hand-off traffic to avoid interference to the GSO arc. There is no basis for distinguishing QGSO systems from any other kind of NGSO system. This has consistently been the U.S. position within the ITU-R.

<sup>158/</sup> Tonga Comments at 2-3. Tonga argues that the "valuable natural asset" of the QGSO orbits must be preserved. Tonga Comments at 3. In fact there is no such thing. All NGSO systems employ valuable orbit and spectrum resources, all of which are "valuable natural assets." The Commission should seek to ensure that these assets are put to the uses deemed to be of the highest public interest.

with GSO systems, the less that system should be required to do with regard to mitigation techniques to co-exist with other NGSO systems.<sup>159/</sup>

These positions are unsupported and completely disregard a key purpose of this proceeding. First, neither party makes any technical demonstration that any proposed QGSO system is more protective of the GSO arc than a comparable (in terms of coverage, capacity, services, etc.) non-QGSO NGSO system. Second, QGSO proponents will be hard-pressed to find a comparable non-QGSO NGSO system. QGSO systems are simply not suited for providing the global, two-way, interactive, services that other NGSO systems are seeking to provide. QGSO systems are inherently regional, and generally operate at altitudes that preclude true interactivity (Denali, for example, proposes to use Ku-band frequencies for DTH services).

The Commission simply cannot achieve the Section 706 and WRC-97 service objectives with QGSO systems of the type currently proposed. The Commission should require all NGSO systems to incorporate sufficient diversity capability to prevent interference to other NGSO systems, so that all systems can participate in the frequency sharing arrangements developed for the band.<sup>160/</sup>

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<sup>159/</sup> Denali Comments at 6-7.

<sup>160/</sup> Denali does not dispute the ability of QGSO-type systems to take steps to employ diversity, stating for example that such systems could compromise on the size and shape of the service windows. Denali Comments at 6. Denali states that it could achieve coordinations with SkyBridge-type LEO NGSO by using spatial diversity and/or carefully coordinating the systems, although it notes that "the achievement of such coordination will involve consideration of factors which are too numerous to discuss here." Denali Comments at 7. Although SkyBridge is skeptical that most QGSO proponents would be willing (continued...)

### 3. "VGSO" Systems

Virgo's "Virtual-geostationary" Orbit ("VGSO") system suffers from the same handicap as QGSO systems. As Denali explains, the Virgo system cuts a large east-west swath which makes it difficult to achieve coordination with both SkyBridge-type NGSO and QGSO systems.<sup>161/</sup> This has not stopped Virgo from making the astonishing claim that "VGSO-type NGSO systems alone promote competition by allowing multiple NGSO systems to share spectrum."<sup>162/</sup>

In fact, interference mitigation among multiple NGSO systems is feasible with Virgo's VGSO system only if all NGSO systems in the Ku-band operate in the VGSO configuration, which Virgo therefore urges the Commission to require.<sup>163/</sup> Virgo describes two sharing methods for coordinating VGSO systems: (1) designing each VGSO system so that its satellites operate only in assigned portions of the sky, and (2) interleaving VGSO satellites within the same orbit planes.<sup>164/</sup> Both techniques would require high level of homogeneity (in fact the second method cited above is the definition of a homogeneous system.) This would be tantamount to orbit

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<sup>160/</sup> (...continued)  
to make the significant design changes required to incorporate sufficient diversity capabilities, SkyBridge agrees with Denali that this is at least theoretically possible. SkyBridge is not asking the Commission to prohibit QGSO systems (or any other kind of NGSO system) from entering the band; it is merely proposing a requirement that all NGSO systems employ sufficient diversity capability to prevent interference to other NGSO systems, and thereby participate in the sharing arrangements developed for the band.

<sup>161/</sup> Denali Comments at 7-8.

<sup>162/</sup> Virgo Comments at iii.

<sup>163/</sup> Id. at i, 3, 8, 21.

<sup>164/</sup> Id. at 19.

planning, which has been rejected on numerous occasions in the ITU-R working groups, including the US delegation. Virgo states that the Commission could permit other types of NGSO systems in the band only if such other systems alone accept the sharing burden and fully protect VGSO systems.<sup>165/</sup> Virgo attempts to justify such proposals by arguing that the VGSO approach is "technically and economically superior, and is the only approach that can be found consistent with the public interest." <sup>166/</sup>

Virgo's claims are absurd. For example, VGSO systems do not achieve an optimized combination of good satellite visibility, low signal propagation delays, and limited satellite handoffs.<sup>167/</sup> In fact, Virgo's claims to low latency, crucial for interactive applications,<sup>168/</sup> are highly exaggerated. The reduction in propagation delay with the Virgo system is only a factor of 1.7 to 4.4 over that of a GSO system; this is simply not sufficient for many applications. LEO systems decrease latency by a factor of 10 over Virgo. Numerous serious broadband proponents have concluded that the low latency afforded by LEO constellations is necessary to provide highly interactive services directly to consumers. The Commission cannot achieve the objectives of this proceeding if it ignores this fact.

Again, SkyBridge is not asking that any particular class of constellation be prohibited from entering the band. It is simply proposing that the Commission

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<sup>165/</sup> Id. at iii, 8.

<sup>166/</sup> Id. at iv; see also id. at 3, 10.

<sup>167/</sup> Id. at 6-7.

<sup>168/</sup> See supra note 51.

require all systems to employ sufficient diversity capability to prevent interference to other NGSO systems, and thereby participate in the sharing arrangements that will be developed for the band. Virgo's proposal that some types of NGSO systems be required to accept all the burden of protecting other systems must be dismissed out of hand.

**B. Band Segmentation**

In its comments, SkyBridge explained that band segmentation is not a viable option, because the provision of the sorts of broadband services intended by Section 706 and WRC-97 requires all of the spectrum that is the subject of this proceeding. No party disagreed with this assessment. Even Boeing, the party that initially proposed band segmentation,<sup>169/</sup> stated that it now questions the advisability of this option, due to the shortage of spectrum, and the promising results of spectrum sharing studies.<sup>170/</sup> Therefore, the Commission should abandon this concept once and for all, and seek more promising ways to ensure implementation of multiple systems.

**C. Other Sharing Techniques**

One party proposes that the Commission adopt minimum size requirements for NGSO gateway earth stations to facilitate NGSO/NGSO sharing.<sup>171/</sup> However, as described above in connection with NGSO/FS sharing, there has simply been no demonstration that arbitrarily restricting the size of gateway antennas will have any significant effect on the ability of NGSO systems to mitigate interference

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<sup>169/</sup> Comments of the Boeing Company, File Nos. 48-SAT-P/LA-97, 89-SAT-AMEND-97, filed December 15, 1997, at 5.

<sup>170/</sup> Boeing Comments at 62.

<sup>171/</sup> Id. at 55.

with each other. The gateway definition adopted to facilitate sharing with FS already guarantees that gateways will be very few in number. The benefits of prohibiting 2.5 meter gateway antennas in favor of 4.5 meter antennas, as Boeing advocates, has simply not be proven.

## **VII. NGSO FSS SERVICE RULES**

### **A. Mitigation Techniques to Protect GSO Arc**

SkyBridge agrees with the Commission's proposal not to place in the Commission's rules any requirement on the specific interference mitigation techniques employed by an NGSO FSS system to protect the GSO arc, and no party provided any reason why such a requirement would be necessary.<sup>172/</sup> The Commission should follow the lead of the ITU-R study groups and rely on the EPFD and EPFD<sub>up</sub> limits, which protect GSO operations no matter what NGSO mitigation techniques are employed.<sup>173/</sup>

### **B. Off-Axis EIRPs**

The only parties commenting on the off-axis EIRP limits to be applied to GSO and NGSO systems in the subject bands support the tentative conclusions of the JTG.<sup>174/</sup> SkyBridge concurs that the Commission should defer to the JTG studies on these issues. However, as explained in the SkyBridge Comments, the ultimate limits should take into consideration the actual protection requirements of GSO and NGSO systems, an aspect of the problem that has not yet been considered in these studies. While SkyBridge supports the work of the JTG on this issue to-date, SkyBridge urges the Commission to allow the JTG work to mature before making final decisions on the off-axis EIRPs to be incorporated in the Commission's rules.

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<sup>172/</sup> Although one party (GE Americom) urges the Commission to require that NGSOs implement arc avoidance measures, GE Comments at 27, no justification was provided as to why such an additional rule is required.

<sup>173/</sup> See also Boeing Comments at 82.

<sup>174/</sup> Loral Comments at 17; Boeing Comments at 82.

### C. NGSO FSS Earth Station Antenna Patterns

In its comments, SkyBridge urged the Commission not to apply the 32-25  $\log\theta$  antenna pattern, which currently governs GSO earth stations under Section 25.209, to NGSO FSS user earth stations.<sup>175/</sup> SkyBridge proposed a more relaxed 36-25  $\log\theta$  pattern, consistent with the small size of the user terminals, which are more analogous to BSS user earth stations than any FSS earth station.<sup>176/</sup> Two parties opposed this proposal;<sup>177/</sup> however, neither party appeared to even acknowledge, much less take into account, the unique characteristics of small NGSO FSS user terminals. The Commission should adopt SkyBridge's proposal, in view of the well-known constraints on the performance of such consumer equipment.

On the other hand, SkyBridge did not oppose the Commission's tighter 29-25  $\log\theta$  antenna pattern for NGSO FSS gateway earth stations, primarily because its gateways are being designed to meet this pattern to facilitate sharing with other services and systems. In addition, this pattern is representative of the performance allowed by technologies for larger antennas. Another NGSO FSS applicant has suggested that this pattern, which exceeds 25.209(2) requirements, be relaxed, and

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<sup>175/</sup> SkyBridge also disagreed with the Commission's proposal that the peak gain of an individual sidelobe may not exceed the prescribed envelope. SkyBridge proposed instead the more usual requirement that the envelope may be exceeded by no more than 10% of the sidelobes, provided no individual sidelobe exceeds the gain envelope by more than 6 dB.

<sup>176/</sup> However, for interference analysis purposes, SkyBridge tentatively proposed that the JTG patterns for GSO earth stations should be used to model NGSO earth stations as well. Studies on this proposal are ongoing.

<sup>177/</sup> GE Comments at 28; Telesat Comments at 8.



that the Commission continue to apply the 25.209(a)(1) pattern.<sup>178/</sup> SkyBridge does not oppose such approach, so long as such pattern is applied in all planes, and not just in the plane of the GSO orbit.

**D. Confirming Compliance with EPFD Limits**

**1. JTG Software Tool**

SkyBridge agrees with several commenters that a meaningful verification process must be developed and enforced, to ensure that all NGSO licensees meet the single entry limits ultimately adopted in this proceeding.<sup>179/</sup> SkyBridge believes that the Commission should use the JTG software tool for assessing compliance with domestic rules and confirming the information that will be sent to the ITU. This tool is simply the most fully developed and carefully examined of all the software resources available. Several commenters agree.<sup>180/</sup>

SkyBridge simply does not understand the position of the sole party, PanAmSat, that urges the Commission to develop its own tool.<sup>181/</sup> The Commission (as well as PanAmSat) is deeply involved in the ongoing specification and validation of the JTG tool, and any concerns that the Commission or PanAmSat has should be addressed in that forum, so that the tool ultimately used by ITU will benefit from their experience. PanAmSat urges that its worldwide systems must be protected; it

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<sup>178/</sup> Boeing Comments at 80.

<sup>179/</sup> See PanAmSat Comments at 3, 15.

<sup>180/</sup> See, e.g., GE Comments at 29; STA Comments at 8.

<sup>181/</sup> PanAmSat Comments at 15.

has every incentive to ensure that the tool to be used on a worldwide basis uses rigorous methodologies and achieves reproducible results.

a. **NGSO FSS System Characteristics to be Provided**

Applicants should be required to provide the Commission with all the NGSO FSS system characteristics called for in the JTG software specification.<sup>182/</sup> However, because providing the details of hand-over and switching strategies is not practical, and because the technique used by the JTG to avoid the need for such information imposes no risk on, and actually further protects, other services, the Commission should not require applicants to provide this information.<sup>183/</sup> SkyBridge agrees with Boeing that the Commission may require disclosure on "the general switching strategies that will be used to avoid interference into GSO systems,"<sup>184/</sup> so long as this means the concepts and principles employed to protect the GSO arc, and not the specific beam switching algorithms or schedules implemented at any given time. As Boeing explained, the actual beam utilization algorithms are proprietary, are likely to continue to evolve over the lifetime of the systems (in order to take into

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<sup>182/</sup> See Loral Comments at 19.

<sup>183/</sup> See SkyBridge Comments at 96.

<sup>184/</sup> Boeing Comments at 85. SkyBridge also agrees with GE and PanAmSat that the Commission should require each NGSO to provide its system characteristics in a transparent manner, GE Comments at 30, and in sufficient detail to allow accurate computerized simulations, PanAmSat Comments at 15. However, as the Commission is well aware, the software tool under development by the JTG is specifically intended to meet these criteria.

account market demand, for example), and are not required for calculation of PFD level by the software tool.<sup>185/</sup>

**b. GSO Reference Antenna Patterns**

The Commission should adopt the GSO reference antenna patterns developed by the JTG for all compliance testing of Ku-band NGSO FSS systems. No party disagreed with this proposal.

**2. Other Compliance Verification Techniques**

DirecTV urges that operational performance of each NGSO system be demonstrated by data and evidence, before any such system is licensed.<sup>186/</sup> As part of such demonstration, DirecTV advocates a thorough inspection by the Commission and GSO industry of all operational software, both terrestrial and satellite.<sup>187/</sup> PanAmSat would require laboratory measurements of all antenna structures in their most critical deployment.<sup>188/</sup> Finally, PanAmSat proposes that operational NGSO systems be tested for compliance, and that the Commission require that compliance reports be provided to the Commission on a monthly or quarterly basis.<sup>189/</sup>

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<sup>185/</sup> Boeing Comments at 85.

<sup>186/</sup> DirecTV Comments at 21.

<sup>187/</sup> Id. at 23.

<sup>188/</sup> PanAmSat Comments at 15. See also Telesat Comments at 5-6.

<sup>189/</sup> PanAmSat Comments at 15-16. In addition, EchoStar argues that the Commission should explicitly require NGSO systems to cease operations or reduce signal strength if they exceed the power limits ultimately placed on them. EchoStar Comments at 7-8. Presumably that is the meaning of any limit or restriction that appears in the Commission's rules or as a condition to a license.

Such procedures would be an absurd waste of time and money. No party has provided any showing whatsoever that the ITU-R compliance verification procedure is not fully adequate to ensure that NGSO systems will meet the EPFD and EPFD<sub>up</sub> limits. Moreover, such proposals would be unprecedented in the satellite industry. For decades satellite providers have successfully shared spectrum without such requirements. Not even secondary services have been subjected to such measures, which could permit operators to stall and increase the costs of competing projects. In this case, PanAmSat and DirecTV are urging that a burden be placed on a co-primary system that is not placed on them.

Rather, administrators have relied on the regulatory regime, including conditions of licenses, to police spectrum sharing. Any party that fails to meet such rules and conditions is subject to being shut-down. To impose such a burdensome regime of testing and scrutiny by competitors, who have already demonstrated in Commission and international proceedings their willingness to act on their anticompetitive motives, would impose undue hardship on NGSO applicants. In the absence of a documented case of actual interference, there is simply no reason to go to such lengths to evaluate such systems. Sufficient detail on these systems is disclosed through the application and software tool verification process; any GSO operator with concerns about the feasibility of the operation of a given system will have ample opportunity to raise its concerns before the Commission and consult with the NGSO operator. Ultimately, the hard EPFD and EPFD<sub>up</sub> limits in the Commission's rules, and the software validation that a system meets those limits, must remain the sole regulatory hurdle for NGSO systems.

Should the Commission nonetheless consider such an approach, the Commission should revise the regime governing the satellite industry and apply such testing to all FSS and BSS systems sharing the subject bands. NGSO FSS operators rely just as much on GSO operators that they are operating in accordance with Commission rules and the conditions of their licenses as GSO operators rely on NGSO licensees. If applied at all, the proposed procedures should be applied across the board on an equal basis to all co-primary systems in the bands.

**E. Emissions**

**1. Emission and Frequency Tolerance Requirements**

SkyBridge believes that Section 25.202 should be applied to both GSO FSS and NGSO FSS systems for the protection of other Ku-band operations. No party expressed any concern that these limits would not be adequate to protect any Ku-band operations, including GSO systems, and the Commission should therefore proceed to adopt them.

**2. Protecting Radio Astronomy**

The National Academy of Sciences ("NAS") urged the Commission to require systems to protect radio astronomy to the level required under ITU-R Recommendation RA.769-1.<sup>190/</sup> SkyBridge agrees that such operations should not be harmed, but, as in the case of GSO systems, no specific rule is required.

As it explained in its comment, the means used by NGSO FSS operators to protect radio astronomy will vary from system to system. In the case of

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<sup>190/</sup> NAS Comments at 1.